Integrated Microelectronic DNA Chip Devices for Genomic Research, DNA Diagnostics, and Potential Nonofabrication Applications

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Presently, active microelectronic DNA arrays are being developed for applications in genomic research and DNA diagnostics. These active microelectronic devices combine the best attributes of both DNA array and "lab on a chip" technologies. These microarray devices are able to create re-configurable electric field transport geometries on the array surface, which allows charged reagent and analyte molecules (DNA, RNA, oligonucleotide probes, amplicons antibodies, proteins, enzymes), nanostructures, cells, and even semiconductor structures to be moved to or from any of the microscopic test sites on the device surface. A research laboratory system is designed to provide the end-user with "make your own chip" capabilities. The system can carry out rapid multiplex hybridization analysis of single nucleotide polymorphisms (SNP), point mutations, and short tandem repeat polymorphisms (STR). Applications include cancer diagnostics, genetic/forensic identification, infectious disease diagnostics, and combinatorial drug discovery. A second miniaturized version being developed, is an integrated microelectronic "sample to answer" portable system. This system is designed with integrated components to carry out cell selection, cell lysis, DNA amplification, multiplex DNA hybridization, and rapid fluorescent analysis via an integrated laser diode/CCD detection system. In another application related to nanotechnolgy, the same microelectronic array devices are used as "Host Boards" for self-assembly of DNA components into more complex structures. DNA molecules, which have intrinsic programmable and self-assembly properties are derivatized with a variety of electronic or photonic donor or acceptor groups, and used for exploring molecular photonic/electronic applications. DNA molecules are also being attached to larger nanostructures, including metallic nanoparticles, organic nanospheres, and to semiconductor microstructures. Electric field assisted self-assembly using active microelectronic arrays is being developed as a "Pick and Place Heterogeneous Integration" process for nanofabrication of two and three dimensional devices and structures within defined perimeters of larger silicon or semiconductor structures. This technology has the inherent hierarchical logic of allowing one to control the organization, assembly and communication of structures and components from the molecular scale ---> to the nanoscale ---> to microscale systems.

Michael J. Heller received his Ph.D. in Biochemistry from Colorado State University in 1973. He was an NIH Postdoctoral Fellow at Northwestern University from 1973 to 1976. Dr. Heller was supervisor of the DNA Technology Group at Amoco Corporation from 1976 to 1984, and then the Director of Molecular Biology at Molecular Biosystems, Inc., from 1984 to 1987. He then went on to Integrated DNA Technologies, where he served as President and Chief Operating Officer from 1987 to 1989. Presently, he is the Chief Technical Officer at Nanogen, Inc., located in San Diego, California. Dr. Heller has extensive industrial experience in biotechnology, with particular expertise in the areas of DNA probe diagnostics, DNA synthesis, and fluorescent based detection technologies. He has been the founder of several new high technology companies. Nanogen Inc., the most recently formed, is directed at the development of novel DNA chip technology. He has numerous publications and patents in the biotechnology and medical diagnostics areas.